

**1 590 750**

# PATENT SPECIFICATION

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## (54) IMPROVEMENTS IN OR RELATING TO THE MANUFACTURE OF KNITTED ARTICLES

(71) We, MACCHINE TESSILI CIRCOLARI MATEC S.p.A., an Italian Body Corporate, of Via delle Nazioni Unite, SCANDICCI, Firenze, Italy, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed to be particularly described in and by the following statement:-

The present invention relates to the manufacture of knitted articles.

There has been proposed in British Patent Specification No. 1,472,728 a process for the manufacture of tights on a circular knitting machine in which the pants portion of the tights is knitted using oscillatory movement of the needle cylinder. During this operation the needles at the end of the active needle arc are progressively excluded and/or re-instated. If the needles are moved directly from their inserted to their excluded position, or vice versa, relatively wide holes or eyelets may be formed in the fabric as will be described in greater detail herein, and these holes may adversely effect the appearance of the finished article.

According to the present invention, there is provided a process for knitting an article on a knitting machine, comprising the step successively excluding single needles at least at one end of an active row of needles during knitting with oscillatory motion of the needle cylinder, at least the said needle to be excluded being moved at least once to a tucked level so that said needle takes the thread without casting off the stitch loop previously formed on said needle when in operation, and then the needle being moved to the excluded position.

Further according to the present invention, there is provided a process for knitting an article on a circular knitting machine comprising the step of successively reinserting into operation single needles at least at one end of an active row of needles during knitting with oscillatory motion of the needle cylinder, the said needle to be inserted being moved at least once to a tucked level, and then being moved to the working level.

Still further according to the present invention, in a circular knitting machine, a needle cylinder capable of oscillatory movement, said needle cylinder including needles, at least two jacks associated with each said needle and comprising a first, lower, jack, and a second jack located above the first jack, said jacks having butts, said first jack being arranged to cause lifting of the needles during oscillatory movement of the needle cylinder, and means for excluding active needles during knitting with oscillatory motion of the needle cylinder, said means comprising cam means cooperating with the second jack of the needle to be excluded so as to raise the needles to a tucked level and then to lower the jack and the needle, and picker means for lowering the said first jack of the needle directly into its excluded position.

The invention will now be described, by way of example only, with reference to the accompanying diagrammatic drawings, in which:

Figure 1 is a perspective view of part of a pair of tights knitted on a circular knitting machine;

Figure 2 shows schematically the needle arcs used to knit the tights of Figure 1;

Figures 3, 4, 5 and 6 show successive stages in the knitting of the tights;

Figure 7 is a developed view of the cam shell of a circular knitting machine according to the invention;

Figure 8 is a fragmentary section of the needle cylinder of the machine;

Figure 9 is a view similar to Figure 7 showing a modified form of can shell; and

Figures 10, 11, 12 and 13 show to an enlarged scale different types of fabric structure obtained by excluding and re-inserting needles in different manners.

In Figures 1 to 6, 11 denotes a first tubular length of fabric intended to form one leg and part of the pants portion of the tights. After knitting this first length 11 with continuous motion of the needle cylinder, the tights being formed are at the stage in Figure 3. Then the needles along a line 13, corresponding to an

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arc A13 (see Figure 2) between points 15 and 17 are excluded. The arc A13 may be for instance about  $90^\circ - 100^\circ$  and may comprise about 100 needles in a machine with a cylinder having 400 needles. Along a needle arc A19 which is complementary to the arc A13, knitting continues with oscillatory motion of the needle cylinder starting from line 19, so as to form a first fabric flap 21 which has a trapezoidal shape; this fabric flap is formed with a progressive reduction of the working needle arc from points 15 and 17 along the arc A19, by progressively excluding the needles along two arcs A23 and A25 adjacent the points 15 and 17 and starting from these points. In this manner inclined sides 23 and 25 are formed, which laterally define flap 21, this being formed in the direction denoted by arrows  $f_7$  from line 19 to an edge 27, extending between points 29 and 31, which are also the ends of sides 23 and 25. The edge 27 corresponds to a needle arc A27.

The progressive exclusion of needles along the arcs A23 and A25 is relatively gradual in that the needles excluded at each end of each course are relatively few in number with respect to the number of needles along the active needle arc. In view of this the sides 23 and 25 of the flap do not have a large inclination, and the angular difference between the arcs A19 and A27 and thus between the line 19 and the edge 27 is limited, the arc of needles A27 possibly being greater than  $180^\circ$ . The last stitches to be formed by the excluded needles remain engaged on these needles as do the stitches formed by the needles along the arc A13. After reaching the edge 27 along the arc A27, the needles between the points 29 and 31 are actuated so as to knit and end flap of a type known *per se*, as denoted by 33, for instance a so-called "anti-ravel tab", so as to permit the needles to abandon the fabric along the arc A27.

When the flap 33 (or an equivalent one has been formed along the arc A27, excluded needles are present along the arc consisting of the arcs A23, A13 and A25, corresponding to the fabric edges 23, 13 and 25 between the points 29 and 31, while cleared, i.e. free, needles are present along the arc A27 between the points 29 and 31. The needles along the arcs A23, A13 and A25 maintain the fabric in a suspended condition. The formation of the tights is now at the stage shown in Figure 4.

At this point, knitting of a fresh fabric portion is begun along the arc of needles A27, with oscillating motion of the needle cylinder, beginning with knitting of an edge 40 of a second trapezoidal fabric flap 41. The edge 40 thus appears in the tights symmetrically with the edge 27. The edge 40 is finished with a flap corresponding to the flap 33, if this latter has a visually distinctive finish which will be prominent in the finished tights; if however, the flap 33 is not prominent, the edge 40 can be started in a conventional manner without any particular finish. The trapezoidal flap 41, which begins at the edge 40, is formed in the direction of arrows  $f_7$  (Figure 5) still using oscillating motion and with gradually increasing numbers of stitches effected by the progressive insertion of needles, starting from the points 29 and 31 along the end arcs A23 and A25; these inserted needles create a knitted connection with the sides 23 and 25 of flap 21.

The flap 41 is substantially symmetrical to the flap 21 and its working front terminates along the lines 43 between the points 15 and 17, with a development along the arc of needles A19. The rate at which the needles are inserted, i.e. at which the stitches are increased, corresponds to that at which the stitches were decreased (i.e. the rate at which needles were excluded) during the formation of the trapezoidal flap 21. When knitting of flap 41 is finished, the tights being knitted are at the stage shown in Figure 6. At this point, along the edge defined by line 43, i.e. along the arc of needles A19 and along the edge defined by line 13 i.e. along the arc A13 (where previously the fabric had been suspended from the corresponding excluded needles during the formation of the flaps 21 and 41), knitting is resumed with a continuous motion of the needle cylinder and with all the needles, so as to form a second tubular length of fabric 46 according to arrows  $f_9$ , symmetrical to the fabric 11, and constituting the other leg and the adjacent part of the pants portion.

Figures 7 and 8 show a circular knitting machine set up to knit the tights in the manner described. In Figures 7 and 8, 61 denotes the needle cylinder in the grooves or tricks of which needles 63 slide, the needles 63 co-operating with sinkers 65 slidably mounted in radial grooves in an annular structure 67 having means for actuating the sinkers. Figure 7 shows the portion of the cam shell of the machine for controlling the needles of the arc A19 which operates to knit the trapezoidal flaps 21 and 41. The portion of the cam shell shown in Figure 7 comprises two zones A and B located on respective sides of an axis X-Y. In each zone a cam assembly is provided to actuate the needles of a respective one of two arcs which together form the arc A19, the needles of arc A13 being temporarily excluded in this stage. In practice the two arcs which form the arc A19 are equal or slightly different.

Lowering cams 69, 70, 71, 72, 73 and 74 cooperate with needle butts to lower the needles. These cams are arranged in a zone containing four feeds for normal (non-elastic) yarn and denoted by 1C, 2C, 3C and 4C respectively; between the feeds 1C and 2C there is a further feed CEA which can be a feed for an elastic yarn or a feed able to supply the elastic yarn and also a normal yarn.

CEB denotes a further feed for an elastic

yarn and, possibly also a normal yarn, this feed being included between the feeds 3C and 4C. To cooperate with the lowering cams, respective countercams are provided, such as that described by 76, as well as a continuous cam 78, the whole being of a type known *per se*.  
 In a zone underlying the assembly of needle-lowering cams and under the continuous cam 78, a set of selection cams can be provided, also of a *per se* known type, to cooperate with butts provided in several rows on selection jacks 82. The jacks 82 are arranged between the continuous cam 78 and a further continuous cam 84 underlying the zone of cams 80, 80A, 80B. A set of cam which provide a selection during knitting of the fabric flaps 21 and 41 cooperate with a further set of jacks having two rows of butts 86A and 86B, the cams of this set being arranged between the underside of the cam 84 and a further continuous cam 85, and beneath the cam 85. The butts 86A correspond to one of the smaller arcs which form the arc A19, while butts 86B correspond to the other of the smaller arcs forming the arc A19. The butts 86A can be moved onto an exclusion or inoperative path 88E, or a working path 88L; similarly the butts 86B can be moved onto an exclusion path 90E or a working path 90L. To obtain the displacement of the jacks 86 by movement of the butts 86A from the exclusion path 88E to the working path 88L, an insertion cam 92 is provided, the cam 92 having an active profile 92A which acts when the needle cylinder and thus the butts 86A move in the direction of arrow FC, which denotes the direction of continuous motion of the needle cylinder. To move the butts 86A from the working path 88L to the exclusion path 88E, an exclusion cam 94 is provided, the cam 94 having an active profile 94A. Similarly, in correspondence of path 90E an insertion cam 96 is provided to lift the butts 86B and thus the jacks 86 from the exclusion path 90E to the working path 90L; an exclusion cam 98 is provided to lower the butts 86B from the path 90L onto the path 90E. The cams 92 and 96 are inserted temporarily at the beginning of the oscillatory motion to raise the jacks 86, and the cams 94 and 98 are inserted temporarily at the end of the oscillatory motion to lower the jacks 86.  
 At least two lifting cam 109 and 111 are provided in correspondence of the lowering cams 71, 70 and 69, 74 respectively to act on the butts 86A when moving along the working path 88L in the zone A. Correspondingly, lifting cams 112 and 113 are provided in correspondence of the lowering cams 71, 72 and 73, 74 respectively, to act on the butts 86B when moving along the working path 90L in the zone B.  
 In correspondence of paths 88L and 88E, two pickers 120 and 122 are arranged; the picker 120, which is an exclusion picker, moves from the working path 88L to the exclusion path 88E the first butt of the row which reaches the picker 120 when the needle cylinder is moved during its oscillatory movement in the direction of arrow fA in the reverse direction to that in which it is rotated during its continuous motion as denoted by arrow fC. The picker 120 which is of a construction known *per se*, is engaged by the first butt of the row and is moved in an inclined direction according to arrow fP<sub>e</sub> so as to lower the butt to the level of the path 88E until it abandons the butt as the butt continues to advance. The picker 122 which is an insertion picker engages the first butt of the row of butts 86A which are moving along the exclusion path 88E and moves this butt in the direction of arrow fP<sub>i</sub> from the path 88E to an intermediate path 88L until it abandons the butt as it advances. The butt is then brought to the path 88L in a manner to be described hereinafter. Likewise, in correspondence of paths 90E and 90L an exclusion picker 124 and an insertion picker 126 are provided and operate similarly to the pickers 120, 122. The exclusion picker 124 is active when the cylinder moves in the direction of arrow fC and the insertion picker 126 is active when the cylinder moves in the direction of arrow fA, to bring the butt 86B of the first jack 86 to an intermediate path 90L, from which it is brought to the path 90L in the hereinafter described manner. The pickers may be constructed as described in Italian patent No. 486,231. The pickers are brought into operation only temporarily from their inoperative positions. The jack 86 shown in Figure 8 is illustrated in its excluded position from which it is moved when one of its butts, for instance the butt 86B, moves from the exclusion path 90E to the working path 90L, until the jack nearly contacts the lower end of the corresponding jack 82 to subsequently raise the corresponding needle 63 when the butt 86B is further raised by the cam 112 or 113 as hereinafter described.  
 The zones A and B of the cam shell may extend along half the circumference of the cam shell or they may each be less than half the circumference. The cam shell may also include further cams within or outside of the zones A and B.  
 The operation of the assembly of cams discussed above will now be described with reference to the process for forming the pair of tights previously discussed with reference to Figures 1 to 6.  
 During the final revolution at the end of the continuous motion by which the first tubular length 11 is obtained, that is when the working front denoted by lines 13 and 19 is reached (the continuous motion with respect to the cam shell being that denoted by arrow fC), the cams 92 and 96 are inserted so that the butts 86A and the butts 86B are brought from the paths 88E and 90E to the paths 88L and 90L respectively so that they are located

on these paths when the movement of the needle cylinder is reversed. When the movement of the cylinder is reversed, the two cams 92 and 96 are excluded, these cams having thus performed the function of raising the jacks 86 from their excluded condition to their working condition. During the first oscillation in the direction opposite the continuous motion of the needle cylinder (i.e. during the first movement according to arrow fA) the butts 86A reach cam 109 and thus cam 111 and are raised by these cams whereby the corresponding needles take the thread from feed 2C and from feed 1C, the needles being lowered each time by the relevant cams 70 and 75 which act on the needle butts. The butts 86B, instead, reach the path 90L and are lifted by the cam 113 and then by the cam 112 whereby the needles take the thread from feed 4C and from feed 3C respectively, the needles being lowered each time by the lowering cams 73 and 71. The movement in the direction of arrow fA is through about 360°. During the return movement in the direction of arrow fC, the butts 86A are lifted at first by the cam 111 and then by the cam 109 whereby the needles take the yarn from the feed 1C and then from the feed 2C, the needles being lowered each time by the lowering cams 69 and 71; the butts 86B are raised at first by the cam 112 and then by cam 113 whereby the needles take the yarn from the feed 3C and then from the feed 4C with the needles being lowered each time by means of the cams 72 and 74 respectively. During each successive reversal in the direction of movement of the needle cylinder, the butts 86A are in the zone B and thus out of phase with respect to the cams 109 and 111 and, similarly, the butts 86B are in the zone A and thus out of phase with respect to the cams 112 and 113. During the oscillatory movement, the cams 94 and 98 are maintained in their excluded positions, and immediately after the raising of butts 86A and 86B the cams 92 and 96 are excluded, as described above.

In this stage the knitted fabric flap 21 is formed, with a progressive reduction in the active needle arc during its formation, in correspondence of sides 23 and 25 where the end needles have to hold the stitches. For this purpose the pickers 120 and 124 are made operative. The picker 120 operates during the movement according to arrow fA after the butts 86A have been raised by the cam 109, in such a manner that the first one of the butts 86A and thus the first of the jacks 86 to meet the picker 120 is lowered according to arrow fPe from the working path 88L to the exclusion path 88E. The picker 124 acts during the movement of the cylinder according to fC, after the cam 112 has acted on the butts 86B, the picker 124 acting to lower from the working path 90L to exclusion path 90E the first butt 86B and thus the first jack 86 which meets the picker 124.

From this above description it follows that during each oscillation of the cylinder, four courses of stitches are formed by the cams 109, 111, 112 and 113, each of which operates twice in one half of the working arc of the needles. 70 During these four courses a needle is excluded by being lowered and thus every four courses a needle is excluded along the lines 23 and 25 respectively by the action of the pickers 120 and 124 respectively. 75

The needle excluded by lowering, if it were to be directly lowered, would form in the finished fabric a relatively wide eyelet or hole as is shown schematically in Figure 13. To avoid this drawback, i.e. to reduce the size of the hole for instance as shown in Figures 10, 11, 12, one proceeds in the manner which will be described hereinafter.

A needle may be excluded from operation either by lifting the needle above the working level (i.e. the level at which a stitch may be formed), or by lowering the needle from the working level. If, during oscillatory motion of the needle cylinder a needle is excluded by displacing it upwardly, it will engage in addition to the loop which it retains, also a thread offered by the feed at which the needle is raised. This provides certain advantages in limiting the size of the holes in the fabric in correspondence of those zones in which a needle is excluded and re-inserted. The hole is thus relatively narrow and not readily visible in the finished garment. 85

However, upwards exclusion does have some drawbacks when working with oscillatory movement with a relatively large number of feeds. In particular the thread of the upstream feed may pass under the sinker nibs; it is necessary to provide a continuous needle latch protecting ring along the whole path, and it is necessary to close the yarn guide mouths from above. On the other hand, using a relatively large number of feeds during the oscillatory movement is of advantage in terms of increased productivity. 90

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The disadvantages discussed in the preceding paragraph are obviated when excluding needles by downwards movement but this results in the large holes being formed in the fabric as discussed above.

By the means now to be described, it is possible to obtain simultaneously the advantages of downwards needle exclusion and those of upwards needle exclusion.

These advantages are obtained by causing initially a partial raising of the needle to be excluded until it reaches a tucked level, i.e. the stitch is not cast off, the needle then being lowered to an exclusion level, the needle in this case holding both the loop last formed by it and which is not cleared, and at least one thread which this needle takes during the short partial raising stage in the exclusion operation. The advantage obtained – and

visible by comparing Figure 13 and Figures 10, 11 and 12 – is achieved also when two, three, four or even more courses of stitches are formed between the exclusion of one needle and the exclusion of the succeeding needle. A further advantage obtained is that of higher strength of the connection between the fabric portions being knitted, for example between the two fabrics flaps 21 and 41 along line 23 of the above specified example.

To obtain a short and partial raising of the needle to be excluded before it is lowered to its excluded position, two pairs of cams 201, 203, and 301, 303 are provided in correspondence of the feeds 1C and 4C, respectively. To cooperate with cams 201, 203 during the movement in the direction of arrow fA, butts 205 are provided in correspondence of zone A for those jacks 82 which correspond to the needles which are to be excluded and then re-inserted singly. Each butt 205 when in its normal working condition follows a path 207L, while, when in its inoperative condition it follows a path 207E; these two paths correspond to the paths 88L and 88E or 90L or 90E. During the movement in the direction of arrow fC the cams 301 and 303 cooperate with butts 209 of the jacks 82 corresponding to the needles which are to be excluded successively and singly; the butts 209 can follow a working path 210L and an exclusion path 210E, which correspond to paths 88L and 88E or 90L and 90E.

The operation of cams 201, 203, 301 and 303 and of the corresponding butts 205, and 209 will be explained with reference to the cams 201, 203 and to the butts 205 during the movement in the direction of arrow fA, the operation of the cams 301 and 303 being equivalent during the opposite movement in the direction of arrow fC.

In the absence of the cams 201 and 203, when moving in the direction of arrow fA the first jack 86 to be excluded will meet picker 120 and this jack will be lowered by means of its butt 86A, moving according to arrow fPe until it reaches the path 88E, the butt will then pass under cam 111 and preferably under a cam 411 to be described hereinafter and which underlies the cam 111. Similarly a cam 413 is located under the cam 113. Only the first jack 86 of the row of jacks is excluded by lowering, and thus the corresponding jack 82 and the needle 63 are lowered, this needle being the first of the row of needles which has traversed the working path corresponding to path 88L. Therefore, under these conditions the picker 120 by its intervention avoids the raising of the needle to be excluded, which is the first of the row of needles still working and advancing in the direction of arrow fA.

However, in the arrangement according to the preferred embodiment of the invention, while the first jack 86 is excluded by the picker 120 through movement of its butt 86A

from the path 88L to the path 88E, the jack 82 is raised by means of its butt 205 engaging the active profile 201A of cam 201 so as to be raised partially by this cam. All of the operative jacks 82 which follow are raised by the profile 1111, which acts on their jacks 86, to the cleared level, this level being such that the butts of these jacks pass over the cam 203. Thus, the jack 82, corresponding to the excluded jack 86, and consequently the respective needle, and only that needle, are raised to a lower level than that at which the needles are normally raised by the cam 111; in other words, while cam 111 acts via the jacks 82, 86 to raise the needles to the cast off or cleared level to take the thread and form a subsequent stitch (this applying for all the needles which move along the path 88L of butt 86A except the first of the needles), the first of the needles, as its jack 86 is no longer active, is raised by cam 201 via the jack 82, only to the tucked level, so that it takes the thread without abandoning the previously formed stitch.

Immediately after the first jack 82 of the row, has been partially raised and has lifted the corresponding needle to the tucked level, it is moved downwardly by the cam 203 to the level 207E of butt 205. In this way both the jack 86 and the jack 82 are now inoperative. The corresponding needle is lowered by the cam 74 and will not be raised again by the action of the cam 111 until its jack 86 has been inserted. In this manner the needle which is about to be excluded, is not excluded directly by lowering but is partially raised to the tucked level and takes the thread from the corresponding feed maintaining its previous stitch; this allows practically the same results to be achieved as would be obtained by excluding the needle by raising the needle and keeping the needle in the raised position, but without the disadvantages discussed earlier.

After knitting the fabric flap 21 with oscillatory motion of the needle cylinder, the pickers 120 and 124 are made inoperative. Starting from the edge 27 and along the reduced arc A27 the flap 33 is formed in a conventional manner. The needles on the arc 27A abandon the stitches while the fabric continues to be held by the inoperative needles along the arc A13 and along the two arcs A23 and A25, the needles along these latter arcs having engaged the stitches and the thread as they have been excluded by lowering via the action of the pickers 120 and 124.

At this time knitting is started along the edge 40, using the needles of arc A27 and fabric flap 41 is knitted with oscillatory motion of the needle cylinder and with a progressive increase in the number of stitches by inserting needles by means of the pickers 122 and 126 which are now made operative. These insertions take place under the action of the picker 122 which acts on the jack butts 86A during the movement in the direction of arrow fA.

fc and under the action of the picker 126 (which acts on the butts 86B) during movement in the direction of arrow fA. During the re-insertion of the end needles, the fabric of the flap 21 previously knitted and that of flap 41, being formed, are progressively connected.

When the flap 41 has been knitted the jacks 86 along the arc A19 are excluded by temporary insertion of the exclusion cams 94 and 98, so as to lower all the butts 86A and 86B from the working path 90L and 88L to the exclusion path 90E and 88E. These jacks are excluded during the initial movement in the direction of continuous rotation according to arrow fc, by the profiles 94A and 98B. After this operation, knitting of the length of tubular fabric 46 is begun along the lines 13 and 43 the needles of the arc A13 being inserted for this purpose.

To further improve the connection between the fabric flaps 21 and 41 by further reducing the width of the holes, the following procedure is used during the re-insertion of the end needles during the oscillatory movement when knitting the flap 41. The needle which is about to be inserted (and which is the first which advances in the direction of movement) instead of being totally raised to clear or cast off the stitch and to take the thread at the feed at which it is actuated for the re-insertion, is raised only partially to the tucked level, so that it takes the thread but keeps the previous stitch loop and is then lowered to its operative level so that at the subsequent feed it will be raised in the same manner as the other working needles; the needle re-inserted into operation comes, as stated above, from a lower, excluded, position.

To achieve the above action, the cams 111 and 113 are provided with a lower concave profile as shown in Figure 7, and the cams 411 and 413 are located beneath the cams 111 and 113 respectively, to define therewith a channel. It should be noted that the cams 411 and 413 are arranged to act on the butts 86A of jacks 86 when these butts are at an intermediate level, that is on the paths 88I and 90I respectively. The butts are moved by this level by the picker 122 during the movement in the direction of arrow fc, and by the picker 126 during the movement in the direction of arrow fA, when these pickers 122 and 126 are made operative to effect the increase in the number of working needles, the pickers 120 and 126 being excluded.

As the operation is similar for the cams 411, 111 and 413, 113 respectively, the operation will be described only for the zone in which the needles are to be inserted during the movement according to arrow fc, by the action of the picker 122 and the cams 411, 111 and 109. When the row of butts 86A of the inoperative needles reaches the actuated picker 122, the first of these butts 86A is raised from the path 88E to the intermediate path 88I, while the other butts of the excluded needles remain on the path 88E beyond the picker 122. Thus the jack 86 is raised to the intermediate path 88I and with it the corresponding jack 82 and needle 63. The butt 86A brought onto the intermediate path 88I is engaged by profile 411A whereby the jack 86 and the associated jack 82 and needle 63 are raised to a tucked level which is determined by the maximum lift provided by the action of the cam 411 on the butt 86A; the butt 86A is then lowered onto the path 88I by the action of the lowering profile 111I of cam 111, so that the butt 86A will engage the active profile 109A of the cam 109 as will the butts of the needles already in operation. It follows that only the needle which is about to be inserted into operation reaches, in correspondence of the feed 1C, the tucked level and takes the thread without casting off its previous stitch, the needle then being lowered so that it will thereafter be raised by the profile 109A of the cam 109, whereas the other operative needles will be raised by the cam 111 at the feed 1C to clear their previous stitches and to take the thread to form the subsequent stitches. The needle that has been made operative at the tucked level is lowered as is all of the other operative needles, by the lowering cam 69, while the associated jack 82 is not lowered to the exclusion level, but is lowered to the path so that its butt moves along the path 207L, and the associated jack 86 is lowered so that its butt moves along the path 88I to be raised, together with the jacks of the other operative needles by the cam 109A.

Similar actions occur during the reciprocating movement in the opposite direction, i.e. in the direction of arrow fA, when the picker 126 and the cams 413 and 113 are active, the picker 124 being excluded.

Figure 9 shows a modified form of cam shell which enables the needle which is about to be excluded to be lifted twice to the tucked level, so as to take two yarns or threads while keeping its previously formed loop before it is lowered to its excluded position in which the butt 86A of its jack 86 is located on the exclusion path 88E or 90E. The cam shell shown in Figure 9 is similar to that of Figure 7, and only the differences between these two arrangements will be described. In the arrangement of Figure 9 the picker 120 has been replaced by a picker 520 in a position between the cams 92 and 109. Thus the jack 86 is excluded before reaching the cam 109 (during the movement in the direction of arrow fA) and thus is not raised at the feed C2 by the cam 109 nor at the feed C1 by the cam 111. In correspondence of cam 109 and therefore of the feed C2, a cam 501 similar to the cam 201 is provided to partially raise the butt 205 as already described for cam 201; thus one obtains a partial raising to the tucked level of the needle to be excluded (the jack 86 of which has been lowered by the picker 520), both at the feed 2C by the cam 501, and subsequently-

after the lowering by cam 70 at the feed 1C by cam 201, the needle then being lowered under the action of the cam 203 which brings the butt 205 to the exclusion path 207E. Thus,  
 5 the needle which is about to be excluded, is raised twice to the tucked level, so that it holds its stitch previously formed and takes the thread from the feeds 2C and 1C before being finally lowered to its excluded position.

10 In the other zone denoted by B there are similar variations with respect to Figure 7, namely, the picker 124 is replaced by a picker 624 in front of cam 112 in the direction of arrow fC, and a further cam 601 is provided,  
 15 similar to the cam 501, to obtain similar functions as described for picker 520 and cam 501.

The differences in the fabric structure obtained by raising the needles at least once to  
 20 the tucked level before being excluded and/or re-inserted, in comparison with that obtained by conventional direct exclusion or re-insertion, may be seen by comparing Figures 10, 11 and 12, with Figure 13. The Figure 10 structure is  
 25 obtained by raising the needle which is about to be excluded only once to the tucked level with a normal re-insertion (i.e. without raising to the tucked level). The Figure 11 structure is obtained by raising twice the needle which  
 30 is about to be excluded whereas that of Figure 12 is obtained by raising twice to the tucked level the needle which is about to be excluded, and raising once to the tucked level the needle which is about to be re-inserted. It will be noted  
 35 that the eyelets or holes produced in the structures of Figures 10 - 12 are progressively reduced with respect to that of Figure 13, which is obtained by directly excluding and inserting the needles.

40 Although the present invention has been particularly described with reference to the process proposed in British patent specification No. 1,472,728 it will be apparent that the invention is also applicable to other processes  
 45 where a progressive exclusion and/or insertion of the needle is required.

**WHAT WE CLAIM IS:**

1. A process for knitting an article on a knitting machine, comprising the step successively excluding single needles at least at one end of an active row of needles during knitting with oscillatory motion of the needle cylinder, at least the said needle to be excluded being moved at least once to a tucked level so that  
 55 said needle takes the thread without casting off the stitch loop previously formed on said needle when in operation, and then the needle being moved to the excluded position.
2. A process according to Claim 1, wherein  
 60 the needle is moved twice to the tucked level before being moved to the excluded position.
3. A process according to Claim 1, further comprising the step of successively re-inserting into operation single excluded needles at least  
 65 at one end of the active row of needles, each

said needle being re-inserted by being moved to the tucked level and then being moved to the working level.

4. A process for knitting an article on a circular knitting machine comprising the step of successively re-inserting into operation single needles at least at one end of an active row of needles during knitting with oscillatory motion of the needle cylinder, the said needle to be inserted being moved at least once to a tucked level and then being moved to the  
 70 working level.

5. A circular knitting machine comprising a needle cylinder capable of oscillatory movement, said needle cylinder including needles, at least two jacks associated with each said needle and comprising a first, lower, jack, and a second jack located above the first jack, said jacks having butts, said first jack being arranged to cause lifting of the needles during oscillatory  
 75 movement of the needle cylinder, and means for excluding active needles during knitting with oscillatory motion of the needle cylinder, said means comprising cam means cooperating with the second jack of the needle to be excluded so as to raise the needle to a tucked level and then to lower the jack and the needle, and picker means for lowering the said first  
 80 jack of the needle directly into its excluded position.

6. A machine according to Claim 5, further comprising additional picker means engageable with the butts of the said first jacks which have been excluded, to raise the first jacks to permit re-insertion of the associated needles, said additional picker means raising the butts of said first jacks to an intermediate level, and first raising cam means engageable with the butt of a said first jack at said intermediate  
 85 level to further raise said butt to a level corresponding to the tucked level of the associated needle.

7. A machine according to Claim 6, further comprising second raising cam means engaging the jack butts of the active needles to raise the  
 90 jacks to a level at which the stitches are cast off, said first raising cam means being arranged beneath the second raising cam means and said second raising cam means having a lower concave profile to permit operation in either  
 95 direction of movement of the oscillating needle cylinder.

8. A machine according to Claim 5, where-  
 100 in said cam means comprises two cams located upstream of the picker means in the instantan- eous direction of movement of the oscillating needle cylinder, same cam acting to raise the second jack twice to a level corresponding to the tucked level of the associated needle before the needle is moved to its excluded position.

9. A machine according to Claim 5, where-  
 105 in the machine comprises symmetrical arrangement of cams for operating the leading needle in the row of active needles in either direction of movement of the oscillating needle cylinder.

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10. A process substantially as hereinbefore described with reference to the accompanying drawings.

11. An article knitted by a process according to any one of Claims 1 to 4 or Claim 10.

5 12. A knitting machine substantially as hereinbefore described with reference to the accompanying drawings.

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Fig.1

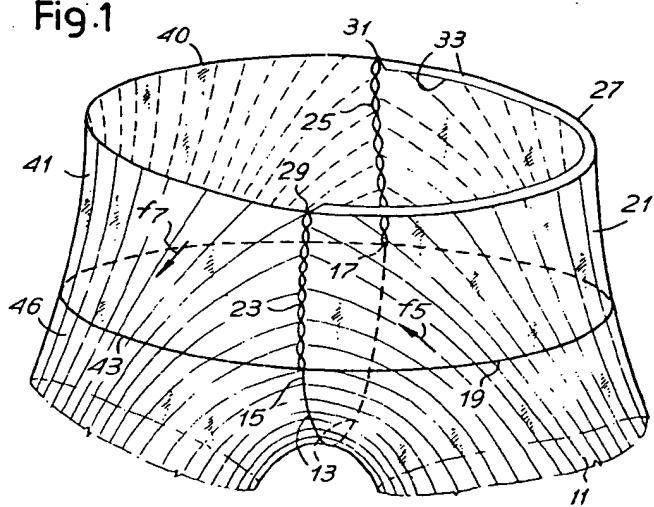
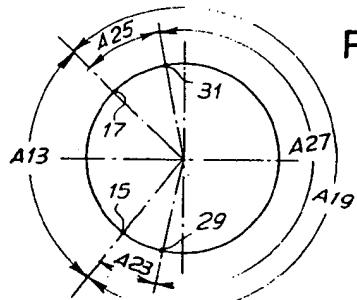
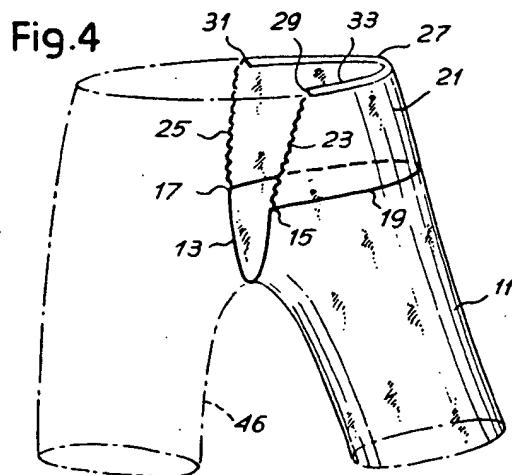
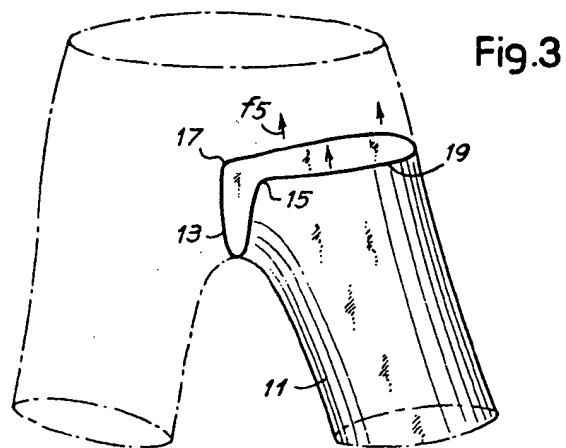


Fig.2



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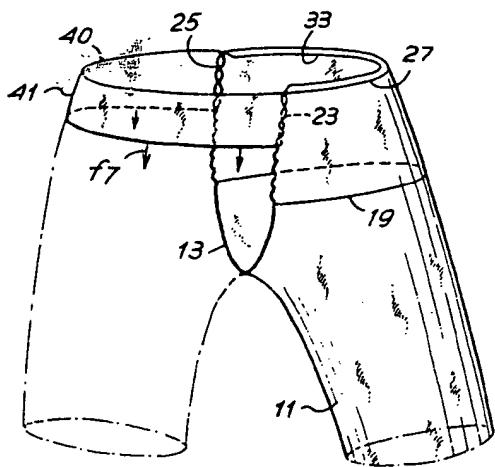


Fig.5

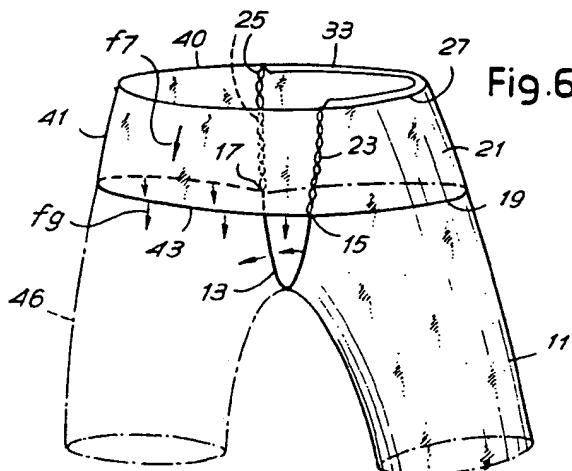
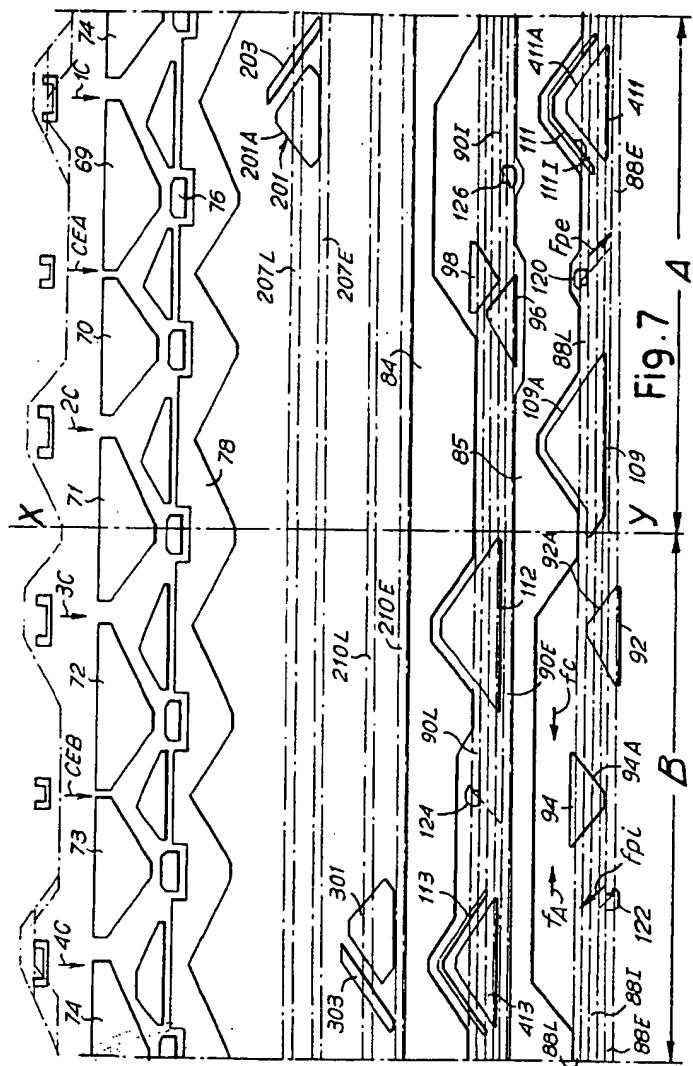


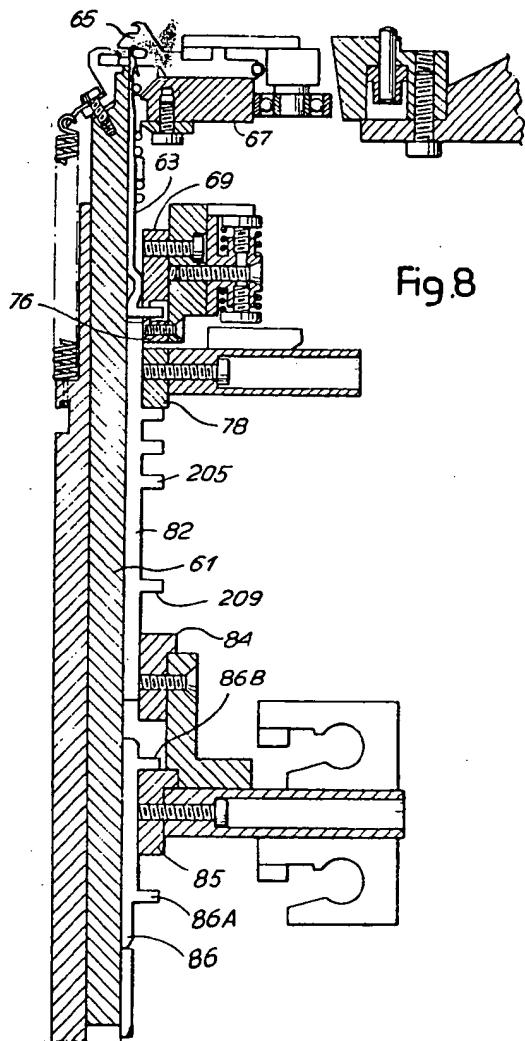
Fig.6

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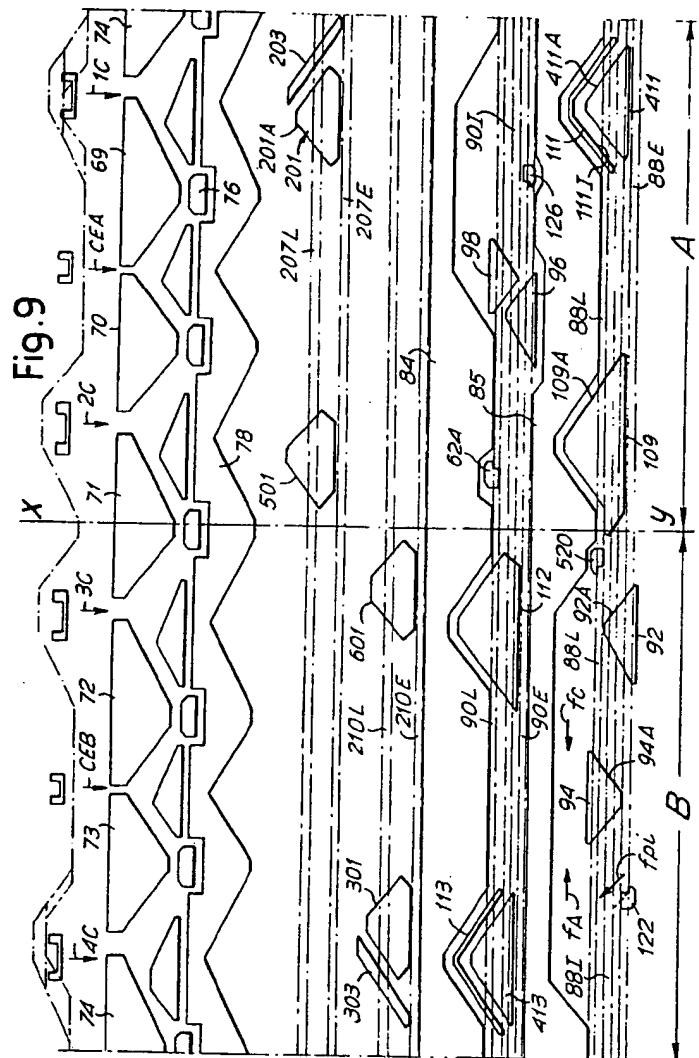
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Fig.10

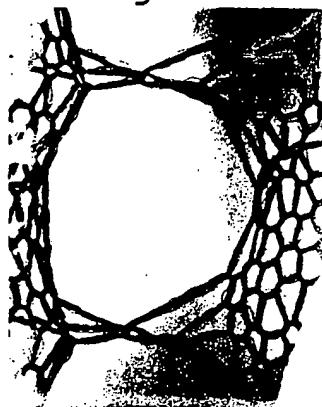


Fig.12

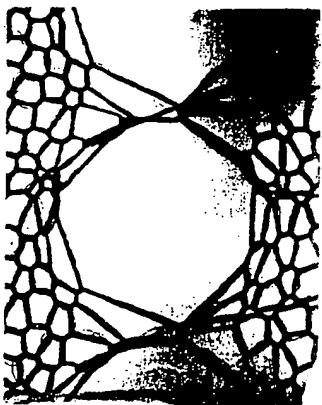
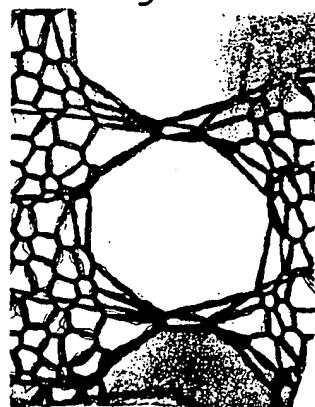


Fig.11



Fig.13

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